COMPACT DRIVE

The present invention relates to a compact drive.

DE 197 14 784 A1 describes a compact drive, which includes an electric motor, at whose one end face a transmission is situated, and at whose other end face a frequency converter is situated. In this case, the electronics region and the motor region must be sealed with respect to the transmission. In this context, it is disadvantageous that the axial length is long and that a power take-off can only be provided at one end face of the compact drive.

Therefore, the object of the present invention is to further develop a compact drive while eliminating the above-mentioned disadvantages. In particular, axial length should be reduced and as many power take-off variants as possible should implementable, i.e. one-sided and two-sided power take-off.

According to the present invention, the object is achieved by the compact drive having the features indicated in Claim 1.

The essential features of the compact drive according to the present invention are that it includes at least an electric motor, a transmission, and a frequency converter, the output shaft of the transmission and the rotor shaft being parallel to each other.

In this context, it is advantageous that the overall axial length is reducible and one-sided and two-sided power take-off may be implemented.

In one advantageous refinement, the electric motor is a synchronous motor. In this case, it is advantageous that high-speed positioning tasks may be executed by the compact

drive and/or a high torque is available over the entire speed range.

In one advantageous refinement, the frequency converter is positioned laterally with respect to the rotor shaft. In this context, it is advantageous that the overall length is reducible and the two sides of the output shaft are accessible, i.e. a two-sided power take-off may be provided.

In one advantageous refinement, the transmission region is sealed with respect to the surroundings, and with respect to the motor region and the compartment for the electronics. In this context, it is advantageous that the transmission region may contain lubricating oil, and that the electronics and the stator and rotor parts remain protected from the lubricant.

In one advantageous refinement, the transmission region, the region of the motor, and the electronics compartment are at approximately the same temperature. In this context, it is advantageous that no thermal barriers are necessary, and therefore, material may be dispensed with and mass and costs may be reduced.

In one advantageous refinement, the motor includes a sensor situated at the one end of the rotor shaft. In this context, it is advantageous that the compact drive may be used for positioning tasks and the sensor is protected by the housing of the compact drive. A brake, which may also be protected by the compact drive, is connectible at the other end of the rotor shaft.

In a further advantageous refinement, the motor does not include a sensor, but the position is ascertained with the aid of an estimation method. This allows axial space to be saved.

A considerable advantage of the present invention is also that the rotor shaft remains completely in the interior of the

housing, and that therefore, no seals are necessary from the rotor shaft to the surroundings. Consequently, a single shaft sealing ring running on the rotor shaft is sufficient. Since the rotor shaft may have a high speed, the amount of heat generated is therefore much less than in the case of a motor having two shaft sealing rings, in particular on its two axial ends of the rotor shaft.

The output shaft may have three shaft sealing rings. However, since the speed is much less than in the case of the rotor shaft, the entire amount of heat generated is less than in the case of a design approach for the drive, where both the rotor shaft and the output shaft have two shaft sealing rings.

In one advantageous refinement of the transmission, at least one spur-gear stage is used, which means that the overall axial length decreases and a solution optimal with regard to costs is produced.

In one advantageous refinement, the transmission stage is designed as a variable transmission having a variable transmission ratio, which means that the wear of the transmission stage is minimized by the speed range, and the torque transmission is adjusted to the loading case. In the case of the variable transmission, it is advantageous that all of the seals for the engine compartment region may even be dispensed with, since a variable transmission, in particular a continuously variable wide-belt transmission, requires no lubricant or only insignificant amounts of lubricant. Therefore, only seals from the interior of the compact drive to the external environment are necessary.

In one advantageous refinement, the rotor shaft and at least one shaft of the transmission are supported in the same housing part. In this context, it is advantageous that the shafts may already be accurately aligned with each other during the manufacturing and machining of the housing part,

for the housing part may be finished during only one instance of chucking, and the relative position of the bearing seats may therefore be aligned in a very accurate manner.

Further advantages are yielded from the dependent claims.

List of Reference Numerals

1	bearing
2	shaft sealing ring
3	housing cover
4	cooling devices
5	shaft sealing ring
6	bearing
7	shaft sealing ring
8	output shaft
9	bearing
10	gear wheel
11	stator
12	permanent magnets
13	rotor shaft
14	pinion
15	shaft sealing ring
16	stator winding
17	electronics compartment
18	bearing
19	resolver stator
20	bearing
21	housing part
22	housing part
23	resolver rotor
31	electronics compartment
40	transmission
51	housing cover
52	housing part
53	lower housing cover
54	smooth grooves
55	power electronics
56	printed circuit board
57	bearing
58	plug-and-socket connector part
59	laminated stator core
60	bearing

61 potentiometer
62 board having connection terminals for motor supply lines
63 plug-and-socket connector part
64 pinion
65 bearing
66 gear wheel
67 gear wheel
68 pinion shaft
69 bearing
70 bearing
71 gear wheel on output shaft
72 bearing
73 output shaft manufactured as a hollow shaft
74 pinion shaft
171 opening for mounting the first intermediate shaft
172 opening for mounting second intermediate shaft
173 PG screw joints

The present invention will now be explained in detail with reference to figures:

An oblique view of a compact drive according to the present invention is drawn in Figure 4, whereby transmission 40 is only indicated symbolically.

An oblique view of a compact drive according to the present invention is drawn in Figure 1.

A sectional view of the compact drive according to the present invention is shown in Figure 2.

Shown in Figure 3 is a sectional view of a compact drive according to the present invention, where, in contrast to Figure 2, the frequency converter and the motor are situated on a different sides of the output shaft.

Shown in Figure 5 is a further exemplary embodiment of the present invention, in which case a three-stage transmission is implemented.

Figure 6 shows a view different from that in Figure 5.

Figure 7 shows an external view of the exemplary embodiment according to Figure 5.

In each instance, transmission 40 symbolically indicated in Figure 4 is implemented differently in different embodiment variants of the present invention. In a first variant, it is designed to be a spur-gear transmission, which is also shown clearly in Figures 2 and 3. In another variant, the transmission from Figure 4 is designed to be a variable transmission. This variable transmission may be manufactured in the form of a VARIMOT transmission of the company SEW-EURODRIVE, i.e. so as to have two disks rubbing together, or in the form of a VARIBLOC transmission of the company

SEW-EURODRIVE, i.e. as a continuously variable wide-belt transmission, the spacing of the two conical adjusting disks determining the transmission ratio. In a further exemplary embodiment of the present invention, a chain may be advantageously used instead of a v-belt.

In the exemplary embodiment of the present invention according to Figure 2, the motor is positioned laterally with respect to the output shaft. Therefore, rotor shaft 13 and output shaft 8 are parallelly situated. The center-to-center distance of these shafts is determined by the engaging parts of the spur-gear transmission stage, which are made up of a pinion 14 connected to rotor shaft 13 in a form-locked or friction-locked manner and a gear wheel 10, which is manufactured as a spur gear and is connected to output shaft 8.

The compartment of the transmission, i.e. the spur-gear transmission stage, is sealed with respect to the space of the electric motor. Shaft sealing ring 15 seals these compartments at the rotor shaft, since the rotor shaft carries permanent magnets 12 in the compartment of the motor, as well as pinion 14 in the compartment of the transmission. Shaft sealing ring 5 seals the compartment of the transmission with respect to the compartment of the motor and output shaft 8, which is manufactured as a hollow shaft.

In a further exemplary embodiment of the present invention, a different transmission containing several transmission stages may be used instead of the spur-gear transmission stage shown.

In a further exemplary embodiment of the present invention, the output shaft does not take the form of a hollow shaft, but rather a solid shaft. In addition, it is also possible to design the output shaft according to the standard for robot interfaces, which means that a highly compact power take-off having a short overall axial length is produced.

Output shaft 8 is supported by bearing 1 in the same housing part 21, in which rotor shaft 13 is also supported by bearing 18.

The compartment of the motor is sealed with respect to the environment, using the shaft sealing ring 2 that runs on output shaft 8 and is inserted into housing cover 3.

Housing parts 21 and 22 are provided with cooling devices 4 for dissipating the heat generated in the motor, transmission, and frequency converter.

Output shaft 8 is supported, in turn, by the other axially opposite bearing (6, 9) in the same housing part 22, in which rotor shaft 13 is also supported by the other bearing 20.

A considerable advantage of the compact drive is that no coupling is necessary between the motor and the transmission, which consequently eliminates the need for additional parts. In particular, the motor and transmission even use the same housing parts in unison. In addition, it is possible to already accurately align the shafts with respect to each other during the processing and machining of the housing part, in that the relative position of the bearing seats for the motor and the transmission, e.g. in particular of bearings 9 and 20, may be set in an extremely accurate manner during manufacturing, for the housing part may be finished in only one machine tool in only one instance of chucking, and therefore the relative position of the bearing seats may be adjusted in a very accurate manner. The common usage of a housing part is also further advantageous in that, in this manner, the compact drive not only requires a small volume, but also has a particularly high strength, since the forces of the motor and the transmission are transmitted to each other inside the same housing part.

The compartment of the transmission is sealed with respect to the environment, using the shaft sealing ring 7 that runs on output shaft 8 and is inserted into housing cover 22.

Stator 11 having stator windings 16 is positioned around rotor shaft 13.

This electric motor is a multiphase synchronous motor. However, in other exemplary embodiments of the present invention, any other motor may be integrated into the compact drive instead of the synchronous motor.

Shaft sealing ring 15, which runs on the rotor shaft and is inserted into housing part 22, seals the compartment of the transmission with respect to the compartment of the motor.

Electronics compartment 17 for the frequency converter is not sealed with respect to the compartment of the motor.

On its one axial end, the motor supports a resolver, which includes a resolver stator 19 and a resolver rotor 23.

Instead of the resolver, other angular-position sensors or angular-velocity sensors may be provided in different exemplary embodiments of the present invention. In other exemplary embodiments of the present invention, a brake may also be integrated into the compact drive on the side opposite to the angular-position sensor.

In other exemplary embodiments of the present invention, the frequency converter is operated, in turn, in such a manner that, with the aid of a method, the angular value is estimated, using a suitable motor model. This allows the overall axial length to be further reduced.

Another variant of an exemplary embodiment according to the present invention is shown in Figure 2, where electronics

compartment 31 is not directly to the compartment of the motor, but output shaft 8 lies between them. In this example, shaft sealing ring 5 seals the compartment of the transmission with respect to electronics compartment 31, shaft sealing ring 5 running on output shaft 8 and being seated in housing part 21.

The transmission may be filled with lubricant, such as lubricating oil, lubricating grease, or the like.

In the shown exemplary embodiments according to the present invention, no particularly effective thermal barrier is provided between the compartments of the frequency converter, i.e. the electronics compartment, and the transmission compartment and the motor compartment. Consequently, the compartments are at approximately the same temperature level. An approximately equal temperature level means a maximum temperature difference of 10°C during continuous operation at nominal load. Of course, a larger temperature difference of the compartments is achievable in the case of short-term, intermittent operation. This design is advantageous and surprising in that no special thermal barrier is necessary, and that the amount of material, mass, and costs may therefore be reduced.

In other exemplary embodiments of the present invention, thermal barriers may also be provided between two or more of the compartments.

In other exemplary embodiments of the present invention, the motor is designed to be multipolar, in particular eight-poled or ten-poled. The motor is advantageously designed according to DE 100 49 883 or DE 103 17 749. Therefore, a single transmission stage, together with such a multiphase motor, is sufficient to cover a wide range of transmission ratios.

In other exemplary embodiments of the present invention, not a hollow shaft, but rather a cylindrical shaft stub is designed as an output shaft, this output shaft being connectible to the device to be driven, via a feather-key connection.

In further exemplary embodiments of the present invention, the output shaft and the output-side housing part are manufactured in accordance with robot interface EN-ISO 9402-1. This allows the overall axial length to be reduced and a high torque to be transmitted. In addition, compatibility with corresponding devices to be driven and connected is achieved.

The electrical connection terminals are provided on the back of the housing and are therefore not visible in Figures 1 through 4. However, other positions for the connection terminals may also be provided in further exemplary embodiments of the present invention.

In further exemplary embodiments of the present invention, the connection terminals are only designed as a power supply. In particular, only electric power cables are run to the compact drive. In this context, the transmission of data to the frequency converter or from the frequency converter to another, in particular, superordinate unit is accomplished by modulating them upon the power lines, the transmission of data being necessary for the data communication. The modulation may be accomplished in a known manner, in particular as known from powerline communication or according to FSK or the FH/PSK method, i.e. Frequency Hopping Phase Shift Keying.

Different views of a further exemplary embodiment according to the present invention are shown in Figures 5, 6, and 7, a three-stage transmission being implemented.

In this context, housing cover 51 is provided for covering the electronics and is rigidly, though detachably, connected to housing part 52 so as to form a seal. The housing cover is

also used for dissipating the heat of power electronics 55 and, to this end, is connected to it in a thermally conductive manner. In addition, the housing cover has smooth grooves 54, i.e. substantially parallel, undulating peaks and depressions, which have the function of a heat sink; liquids, such as water or juice, being able to drain off easily, and the risk of corrosion and soiling of the housing being consequently reduced. Housing part 52 has the function of forming the housing for the motor and the transmission, a lower housing part 53 being provided on it.

The electronics include several boards, which are interconnected electrically and/or mechanically.

Three of these boards are schematically indicated, a first supporting signal electronics and power electronics 55, a second board 56 connected to the first board supporting a plug-and-socket connector part 58.

The rotor shaft of the motor is supported in housing part 52 by bearings 57 and 60 and is connected to a potentiometer 61 on one of its ends.

Laminated stator core 59 is connected in housing part 52.

Board 62 is manufactured to have connection terminals for motor supply lines and network supply lines. Other lines may also be connectible here, such as temperature-sensor lines for the stator windings of the motor and lines of potentiometer 61 provided on the one end of the rotor shaft. The signal electronics and power electronics are electrically connected via plug-and-socket connector part 58, which is connected on mounting board 62, in particular soldered, and via corresponding plug-and-socket connector part 63, which is connected to mounting board 56. The power supplied to the electronics is also fed to board 62 via PG screw joints 173.

Pinion 64 is rigidly connected to the rotor shaft; in particular, they are advantageously manufactured in one piece, pinion 64 engaging with a gear wheel 66, which is mounted on a first intermediate shaft that carries, in turn, a pinion-shaft segment 74. This last-mentioned pinion-shaft segment engages with a gear wheel 67, which is mounted on a second intermediate shaft. Bearings 65 and 69 are used for supporting the second intermediate shaft, which supports gear wheel 67 and includes a pinion-shaft segment 68. Pinion-shaft segment 68 engages with a gear wheel 71, which is mounted on output shaft 73 that is designed as a hollow shaft.

Output shaft 73 is supported by bearings 70 and 72 in housing part 52.

Mounting opening 171 for the first intermediate shaft and mounting opening 172 for the second intermediate shaft are shown in Figure 7. They are imperviously sealed by suitable covering means.

PG screw joints 173 are provided on housing part 52 and are used for feeding cables through to the connection terminals of board 62. Electric conductor tracks lead from there to plug-and-socket connector 58, and from there to the electronics, via plug-and-socket connector 63 and board 56. The supply lines for the motor run, in turn, from power electronics 55, via board 56 and plug-and-socket connectors 58 and 63 and the connection terminals on board 62, to the stator of the motor.